AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (currently amended): A tire design method comprising the steps of:

(a) determining a neural network conversion system in which a correspondence between design parameters of a tire, which represent any one of a cross-sectional configuration of the tire including an internal structure and a structure of the tire, and performances of the tire, which have a plurality of extremums, is established;

(b) determining an objective function which expresses said performances of the tire and setting a constraint condition which constrains an allowable range of at least one of said performances of the tire and manufacturing conditions of the tire; and

(c) determining a design parameter of the tire, which gives an optimum value of an objective function, based on said objective function and said constraint condition by using the neural network conversion system determined in said step (a) to design the tire based on the design parameter of the tire to output calculation result of the optimized tire.

2. (previously presented): A tire design method according to claim 1, wherein said step (c) comprises the steps of:

defining the design parameter of the tire as a design variable;

obtaining a value of the design variable, which gives the optimum value of the objective function, by using the neural network conversion system determined in said step (a) while considering the constraint condition; and

designing the tire based on the design variable which gives the optimum value of the objective function.

3. (previously presented): A tire design method according to claim 2, wherein said step (c) comprises:

predicting an amount of change in the design variable which gives the optimum value of the objective function while considering the constraint condition based on a sensitivity of the objective function which is a ratio of an amount of change in the objective function to a unit amount of change in the design variable and a sensitivity of the constraint condition which is a ratio of an amount of change in the constraint condition to a unit amount of change in the design variable;

calculating a value of the objective function when the design variable is changed to correspond to a predicted amount and a value of the constraint condition when the design variable is changed to correspond to a predicted amount; and

based on the predicted and calculated values, obtaining a value of the design variable, which gives the optimum value of the objective function, by using the neural network conversion system determined in said step (a) while considering the constraint condition.

4. (previously presented): A tire design method according to claim 1, wherein said step (c) comprises the steps of:

(d) selecting, as a design variable, one of the design parameters of the tire included in the neural network conversion system determined in said step (a);

(e) changing a value of the design variable selected in the neural network conversion system determined in said step (a) until the optimum value of the objective function is given by using the neural network conversion system determined in said step (a) while considering the constraint condition; and

(f) designing the tire based on the design parameter of the tire obtained by the design variable which gives the optimum value of the objective function.

5. (original): A tire design method according to claim 4, wherein said step (b) comprises the step of determining a constraint condition which constrains an allowable range of at least one of tire performances other than said determined objective function and the design parameters of the tire.

6. (previously presented): A tire design method according to claim 4, wherein said step (e) comprises:

predicting an amount of change in the design variable which gives the optimum value of the objective function while considering the constraint condition based on a sensitivity of the objective function which is a ratio of an amount of change in the objective function to a unit amount of change in the design variable and a sensitivity of the constraint condition which is a ratio of an amount of change in the constraint condition to a unit amount of change in the design variable;

calculating a value of the objective function when the design variable is changed to correspond to a predicted amount and a value of the constraint condition when the design variable is changed to correspond to a predicted amount; and

based on the predicted and calculated values, changing a value of the design variable to be selected until the optimum value of the objective function is given by using the neural network conversion system determined in said step (a) while considering the constraint condition.

7. (previously presented): A tire design method according to claim 1, wherein said step (c) comprises the steps of:

defining the design parameters of the tire in the neural network conversion system determined in said step (a) as base models to determine a group for selection comprising a plurality of base models;

determining said objective function, a design variable, a constraint condition and an adaptive function which can be evaluated from the objective function for each base model of the group for selection;

selecting two base models from the groups for selection;

effecting at least one of producing new base models by intersecting the design variables of the two base models at a predetermined probability with each other and producing new base models by modifying in part the design variables of at least one of the two base models;

obtaining an objective function, a constraint condition, and an adaptive function of the base models using the neural network conversion system determined in said step (a) by changing the design variable;

storing the base models whose design variables have been changed and base models whose design variables have not been changed;

repeating the storing step until the number of the stored base models reaches a predetermined number;

determining whether a new group comprising the stored base models of the predetermined number satisfies a predetermined convergence condition;

wherein if not, the above steps are repeated until with the new group defined as the group for selection the group for selection defined satisfies the predetermined convergence condition; and

if the predetermined convergence condition is satisfied, designing a tire based on the design parameters of the tire obtained by the design variable, which gives the optimum value of the objective function, among the predetermined number of the stored base models by using the neural network conversion system determined in said step (a) while considering the constraint condition.

8. (previously presented): A tire design method according to claim 1, wherein in said step (a), said neural network conversion system is constructed with data in a multi-layered feed forward type neural network which has learned so as to convert the design parameters of the tire to performances thereof.

9. (original): A tire which is formed according to design parameters designed by a tire design method according to claim 1.

10. (previously presented): An optimization analyzing apparatus comprising:

neural network conversion system calculating means for obtaining a corresponding relation between design parameters of a tire and performances of the tire, which have a plurality of extremums;

input means for inputting an objective function and a constraint condition as optimizations by determining the objective function which expresses the performances of the tire and also by determining the constraint condition which constrains an allowable range of at least one of the performances of the tire and manufacturing conditions of the tire; and

optimization calculation means for obtaining a design parameter of the tire which gives an optimum value of the objective function based on the optimization items inputted by said input means using said neural network conversion system calculation means.

11. (previously presented): An optimization analyzing apparatus according to claim 10, wherein said neural network conversion system calculation means is provided to obtain a non-linear corresponding relation between, on the one hand, the design parameters of the tire, which have the plurality of extremums, and a condition to be applied to the tire, and on the other hand, the performances of the tire.

12. (previously presented): An optimization analyzing apparatus according to claim 10, wherein said optimization calculation means comprises:

selection means which selects one of the design parameters of the tire included in said neural network conversion system calculation means as a design variable;

changing means for changing a value of the design variable selected from said neural network conversion system calculation means until the optimum value of the objective function is given, while considering the constraint condition;

optimum value calculation means for calculating a value of the design variable until the optimum value of the objective function is given by using said neural network conversion system calculation means; and

design means for designing a tire based on the design parameter obtained by the design variable which gives the optimum value of the objective function.

13. (previously presented): An optimization analyzing apparatus according to claim 10, wherein said optimization calculation means comprises the steps of:

defining the design parameters of the tire in the corresponding relation determined in said neural network conversion system calculation means as base models to determine a group for selection composed of a plurality of base models;

determining said objective function, a design variable, a constraint condition, and an adaptive function which can be evaluated from the objective function for each base model in the group for selection;

selecting two base models from the group for selection;

effecting at least one of producing new base models by intersecting the design variables of the selected two base models at a predetermined probability with each other and producing new base models by modifying in part the design variables of at least one of the two base models;

obtaining an objective function, a constraint condition, and an adaptive function of the base models which have been produced using said neural network conversion system calculation means by changing a design variable;

storing the base model whose design variables have been changed and a base model whose design variables have not been changed;

repeating the storing step until the number of the stored base models reaches a predetermined number;

determining whether a new group comprising stored base models of the predetermined number satisfy a predetermined convergence condition;

wherein if not, the new group is defined as the group for selection and the above steps are repeated until the group for selection defined satisfies the predetermined convergence condition; and

if the predetermined convergence condition is satisfied, designing a tire based on a design parameter of the tire obtained by the design variable, which gives the optimum value of the objective function, among the predetermined number of the stored base models by using said neural network conversion system calculation means while considering the constraint condition.

14. (previously presented): An optimization analyzing apparatus according to claim 10, wherein said neural network conversion system calculation means is a multi-layered feed forward type neural network which has learned so as to convert the design parameters of the tire to the performances thereof.

15. (currently amended): A ~~storage~~ computer readable medium having a stored optimization analyzing program for design of a tire executed by a computer, wherein the optimization analyzing program is provided to:

determine a corresponding relation by neural network conversion between design parameters of a tire and performances of the tire, which have a plurality of extremums;

determine an objective function which expresses the performances of the tire and determine a constraint condition which constrains an allowable range of at least one of the performances of the tire and manufacturing conditions of the tire; and

obtain a design parameter of the tire, which gives an optimum value of the objective function, based on the determined corresponding relation, the objective function, and the constraint condition to design a tire based on the design parameter of the tire.

16. (currently amended): A ~~storage~~ computer readable medium having a stored optimization analyzing program for design of a tire according to claim 15, wherein the design of a tire based on the design parameters of the tire comprises:

selecting, as a design variable, one of the design parameters of the tire included in the determined corresponding relation based on the determined corresponding relation, the objective function, and the constraint condition;

changing a value of the design variable selected from the determined corresponding relation until the optimum value of the objective function is given while considering the constraint condition; and

designing the tire based on the design parameter of the tire obtained by the design variable which gives the optimum value of the objective function.

17. (currently amended): A ~~storage~~ computer-readable medium having a stored optimization analyzing program for design of a tire according to claim 16, wherein the constraint condition constrains an allowable range of at least one of the performances of the tire other than the determined objective function and the design parameters of the tire.

18. (currently amended): A ~~storage~~ computer-readable medium having a stored optimization analyzing program for design of a tire according to claim 16, wherein the change of the design variable is effected by:

predicting an amount of change in the design variable which gives the optimum value of the objective function while considering the constraint condition based on a sensitivity of the objective function which is a ratio of an amount of change in the objective function to a unit amount of change in the design variable and a sensitivity of the constraint condition which is a ratio of an amount of change in the constraint condition to a unit amount of change in the design variable;

calculating a value of the objective function when the design variable is changed to correspond to a predicted amount and a value of the constraint condition when the design variable is changed to correspond to a predicted amount; and

changing a value of the design variable to be selected based on the predicted and calculated values until the optimum value of the objective function is given while considering the constraint condition.

19. (currently amended): A ~~storage~~ computer-readable medium having a stored optimization analyzing program for design of a tire according to claim 16, wherein the design of a tire based on the design parameter of the tire comprises:

defining the design parameters of the tire in the determined corresponding relation as base models to determine a group for selection composed of a plurality of base models;

determine said objective function, a design variable, a constraint condition, and an adaptive function which can be evaluated from the objective function for each base model in the group for selection;

selecting two base models from the groups for selection;

effecting at least one of producing new base models by intersecting the design variables of the selected two base models at a predetermined probability with each other, and producing new base models by modifying in part the design variables of at least one of the two base models;

obtaining an objective function, a constraint condition, and an adaptive function of the base model using said neural network conversion system calculation means by changing design variables;

storing the base models whose design variables have been changed and a base model whose design variables have not been changed;

repeating the storing step until the number of the stored base models reaches a predetermined number;

determining whether a new group comprising the stored base models of the predetermined number satisfies a predetermined convergence condition;

wherein if not, the new group is defined as the group for selection until the group for selection defined satisfies the predetermined convergence condition; and

if the predetermined convergence condition is satisfied, designing a tire based on the design parameter of the tire obtained by the design variable, which gives the optimum value of the objective function, among the predetermined number of the stored base models by using the corresponding relation while considering the constraint condition.